ON THE

ORIGIN AND DEVELOPEMENT

OF THE

PULPS AND SACS OF THE HUMAN TEETH.

By John Goodsir, Junior,

Surgeon, Anstruther, Fifeshire.

(From the Edin. Med. and Surg. Journal, No. 138.)

"Il est peu de sujets en medecine sur lesquels on ait tant écrit que sur les dents; deux cent volumes contiendraient à peine tout ce qu'on en a imprimé! Mais est-ce à dire que tout soit connu à cet egard? Est-ce à dire que la matière ait été epuisée et qu'il ne reste plus rien à faire? Nullement. L'Anatomie n'a pas encore le dernier mot de la nature sur cet intéressant sujet, et il reste encore, quoiqu'on en dise, quelques doutes à eclaircir et plus d'une difficulté à résoudre."

Blandin, Anat. du Systeme Dentaire, 1836.

Section I.—Examinations of the dental arches at different ages.

1. An embryo (Fig. 1,) which measured $7\frac{1}{2}$ lines from the vertex to the point of the coccyx, weighed 15 grains, and appeared to be about the sixth week,* was selected and prepared for the purpose of examining the state of the palate and dental arches.

* It is difficult to determine the exact age of an embryo. The ages given in the text, therefore, must be considered as approximations, being probably rather underrated. I have given a full-sized sketch of the youngest subject in which I have observed any of the phenomena of dentition, with the weight and measurements of a few of the others. In researches of this kind, the sequences of phenomena are of more importance than their periods of appearance.

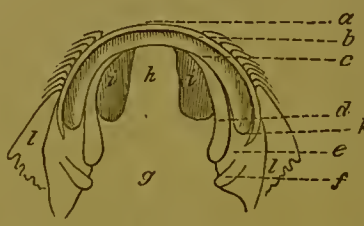
Velpeau, Embryologie ou Ovologie Humaine—Breschet, Etudes Anatomiques, &c. &c. de l'œuf dans l'espece humaine—Sœmmering, Icones Embryonum Humanorum.

The cheeks were divided transversely from the commissures of the lips with fine scissors; the jaws were separated, removed, and fixed to the bottom of a small capsule full of water. The point of the tongue was removed. The configuration of the mouth was then determined by means of a half-inch lens and two needles, bent at the points, and fixed in slender handles.

Fig. 1.

Upper Jaw.—The roof of the mouth was bounded anteriorly and laterally by the free edge of the lip, (*a*, Fig. 2,) which is at this age thin and of great transverse extent. Within the lip (*a*,) but separated from it by a groove, (*b*,) to be more particularly described afterwards, there was observed a lobe of a horse-shoe shape (*c*,) narrow anteriorly at the median line, broader, flatter, and of a rounded form on each side posteriorly. Coming out from above the internal posterior edges of this lobe (*c*,) and firmly adhering to it, two other lobes (*d d*) were seen; flat, rounded, and curving backwards and inwards posteriorly, gradually disappearing by pointed extremities anteriorly. From the posterior extremities of each of the lobes now described (*d d*,) and of the horse-shoe lobe (*c*,) a thin semitransparent membranous fold (*e e*) passed backward on each side, attached externally to the sides of the capacious bucco-pharyngeal cavity, bounded internally by a free edge opposed to its fellow of the opposite side, and terminating posteriorly on the lateral walls of the pharynx. Adhering to the inferior surface of each of these folds was seen a smaller lobe (*f f*) somewhat similar to the two last, and situated a little behind them. The needle placed under the folds showed that they were free and floating, except at their exterior or adherent edges, and that they constituted a partial division of the large common nasal, buccal and pharyngeal cavity into a superior and an inferior compartment. The upper wall of this common cavity was smooth and flat posteriorly (*g*); but anteriorly it was contracted and terminated in a longitudinal bar (*h*,) which ran forwards to be attached to the superior surface of the horse-shoe lobe at the median line, and to the other parts in that neighbourhood. Under the bar (*h*) a deep cavity (*i i*) was seen, which communicated with the exterior of the face by two small *foramina*, which constituted at this period the whole external nasal organ. As before-mentioned, a groove (*b*) was observed between the lip (*a*) and the external edge of the horse-shoe lobe (*c.*) This groove (*b*) was deep, and its walls and lips were in close apposition. It terminated posteriorly on each side (*k k*) by

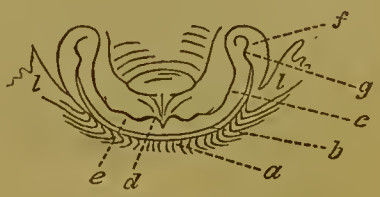
Fig. 2.



becoming more shallow, and curving backwards and inwards on the inferior surface of the membranous folds (*e e.*) There was a median frenum between the lip and the horse-shoe lobe.

Lower Jaw.—The under lip (*a*, Fig. 3,) resembled the upper, and was separated along its whole extent by a groove (*b*) similar to the one above, from a semicircular lobe, (*c.*) Anteriorly this lobe (*c*) was divided into two median large (*d d*,) and two lateral smaller lobules (*e e*,) the whole being firmly adherent to the floor of the mouth in front of the tongue and its *frenum*, which were both well developed. The lateral parts of the lobe (*c*) were rather indistinct, but at the point where the free edge of the lip terminated, it extended transversely and posteriorly, became thick and bulbous (*f f*,) and exhibited on its surface a narrow shallow groove of a sigmoidal form (*g g*,) which was continuous with the groove behind the lip. There was a median labial frenum.

Fig. 3.



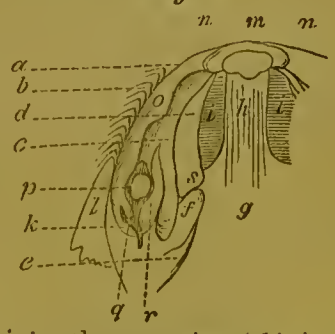
On the external sides of the membranous folds in the upper, and of the posterior parts of the lobe in the lower jaw, the cut surfaces of the cheeks made by the scissors were seen, (*l, l, l, l.*)

The mucous membrane over its whole extent was thin, and of a grayish-yellow colour, the lobes granular, very friable, and of a dead white. The breadth of the upper alveolar arch was $1\frac{1}{3}$ line, the length of the same was 1 line.

2. The jaws of an embryo which measured 1 inch, weighed 20 grains, and appeared to be about the seventh week, were prepared and examined as in the former case.

Upper Jaw.—The free edge of the lip (*a*, Fig. 4,) was not so extended as at the sixth week. The horse-shoe lobe (*c*,) had become broader and more developed posteriorly, and anteriorly exhibited three lobules, one median (*m*,) and two lateral and anterior (*n n.*) The two lobes observed on each side of the palate in the former embryo (*d d, f f*, Fig. 2,) had disappeared, having apparently coalesced; the posterior one (*f*) being curved forwards to join the anterior (*d*,) in the point (*s*, Fig. 4,) while the combined mass had contracted itself

Fig. 4.



towards the front of the mouth within the limits of the horse-shoe lobe (*c*.)

The cleft had slightly diminished, but was still of sufficient width to display the whole of the undivided nasal cavity.

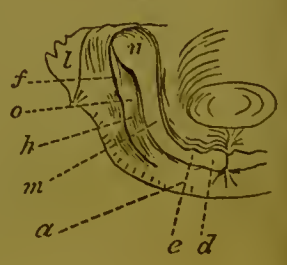
The lip (*a*) was so lax as to admit of being moved by the middle. The horse-shoe lobe (*c*) could also be pressed by the same means inwards and backwards. When these two parts were separated, the mucous membrane was seen to form a duplicature (*b*,) between the lips and a ridge (*o*,) which extended from the posterior part of the dental arch, to the outer extremity of the lateral lobule (*n*.)

The median portion of the dental arch was formed by the two lateral lobules (*n n*,) which separated the lips from the median lobule (*m*,) and extended also a little on each side of it.

The lateral portions of the arch presented externally the ridge (*o*,) formerly mentioned, smooth and convex on its external surface, internally moulded into three curves, the anterior long and shallow, the second deeper, the third or posterior almost semicircular. Behind the last curve, the internal edge of the ridge formed a deep notch, which swept outward and forward, so as to mould the former into an almost isolated lobule (*q*.) The ridge now disappeared, but its edge continued backwards and inwards, winding around the posterior extremity of the horse-shoe lobe (*c*,) so as to form a groove (*k k*, Figs. 2 and 4,) on the surface of the soft mucous membrane. The internal division of the lateral parts of the dental arch was formed by three bulgings, apparently productions from the horse-shoe lobe (*c*,) and which were separated from the curves of the ridge (*o*,) by a groove which was deeper at their sides than in their intervals. The anterior one was lengthened and indistinct, the middle one was more developed, the posterior circular, convex, and altogether isolated. The isolation of this bulging was produced by a longitudinal lobule (*r*,) apparently cut off from the external edge of the horse-shoe lobe (*c*,) and forming a partial inner ridge corresponding with the outer one. This new lobule (*r*,) reached back as far as the posterior extremity of the horse-shoe lobe (*c*,) and terminated anteriorly near the middle of the centre bulging.

Lower Jaw.—In the situation of the dental arch, there existed a groove (*h*, Fig. 5,) very distinct posteriorly, but having no outer lip anteriorly. The inner lip (*m*,) presented posteriorly a large lobe (*n*,) under which the needle was easily inserted for a short distance. In the middle, this lip (*m*,) was thin, elevated, and curved over the groove (*h*.) Anteriorly it became broader, and

Fig. 5.



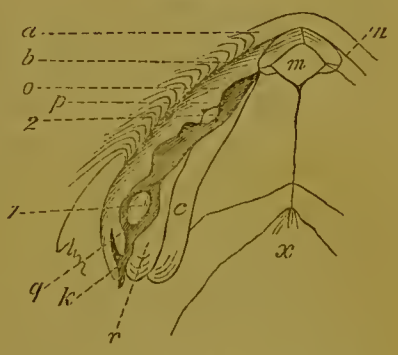
curved still more over the groove, and was divided into two median larger lobules (*d*,) and two lateral smaller (*e*.) Between the two median (*d*,) there was a notch at the attachment of the lingual frenum. The outer lip (*f*,) was deficient anteriorly, so that the groove was bounded in that situation by the under lip (*a*,) which was loose, free, and turned outwards. Posteriorly the outer lip (*f*,) was well developed, and came out from under the posterior lobe (*n*,) of the inner lip, so as to render the groove (*h*) pointed, and curved backwards and inwards. This lip (*f*,) extended only about half way towards the median line, and appeared flat, or in the same continuous plane with the floor of the groove. It was also curved outwards, so as to overhang the labial mucous membrane.

The groove presented an elevation (*o*,) of its floor, near its posterior extremity. There was a labial frenum. The mucous membrane possessed the same physical properties as at the sixth week. The lobes were not so granular, but tougher and more consistent. Breadth of superior arch $1\frac{1}{2}$ line, length 1.

3. The jaws of an embyro at the second month having been prepared in the usual manner, presented the following appearances.

Upper Jaw.—The lip (*a*, Fig. 6,) was more movable, and its free edge less extended. The cleft in the palate had diminished, existing only as a small angular deficiency (*x*,) in the pendulous portion. The horse-shoe lobe was still perceptible under the form of a bulging (*c*,) represented as turned aside to exhibit the objects under it. The lobule (*r*) had increased in size, so as to extend farther backwards, and to appear on the posterior lateral parts of the palate. The median lobule (*m*) had become triangular, the anterior edge being formed by the curve of the palate somewhat pointed in front, the lateral edges being straight and meeting in an angle behind, from which the median line of suture or raphe of the palate proceeded. The median lobule (*m*) had increased relatively, the lateral lobules (*n n*) only absolutely. The posterior portion of the dental groove (*k*) was longer, wider, and not so much curved.

Fig. 6.



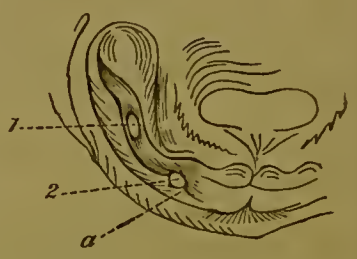
The bulging or papilla (1) was more distinctly isolated ; and at the anterior extremity of the second curve in the ridge (*o*,) another papilla (2) had appeared as a production from the latter. This papilla (2) was bounded externally by a lamina (*p*,) which

was also a production from the edge of the ridge (*o*,) and was notched at its inner margin, where it was applied to the side of the papilla.

The dental groove then terminated in a point, at the outer extremity of the lateral lobule (*n*.) There was a labial frenum.

Lower Jaw.—The posterior portion of the dental groove had undergone no material change, but had become deeper, and contained in the situation of the elevation marked (*o*, Fig. 5,) a distinct rounded papilla (1, Fig. 7). Further on, another papilla (2) bounded externally by a notched lamina (*a*) had appeared. This combined papilla and lamina was exactly similar in its configuration and relations to that marked (2, Fig. 6). The anterior part of the groove had become more distinct, not because it had acquired an outer lip, but because its floor had risen above the level of the labial mucous membrane. There was a labial frenum.—The breadth of the superior arch was $1\frac{2}{3}$ line ; length $1\frac{1}{3}$.

Fig. 7.



4. The jaws of an embryo nine weeks old were examined under water.

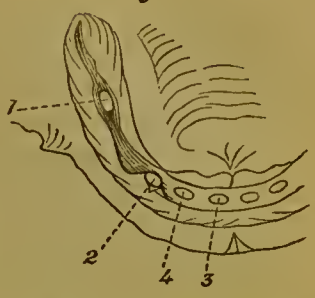
Upper Jaw.—No material change had taken place in the configuration of the palate, except that the median lobule (*m*, Fig. 8,) had diminished relatively, and in the transverse direction, while the lateral lobules (*n*, *n*,) had increased relatively, and also in the transverse direction. A longitudinal lobule (*y*,) had also appeared on the surface of the median lobule (*m*.) The cleft (*x*) in the soft palate was smaller. The posterior part of the dental groove was wider. The papilla (1,) had become more prominent, and the lips of the groove had almost met before and behind it. The papilla (2) is larger. A little further on, corresponding with the lateral lobule (*n*) on each side, two papillæ (3 and 4,) with notched laminæ in front of them, had appeared. The centrals (3,) or those on each side of the median line, were the most distinct.

Fig. 8.

Lower Jaw.—The lips of the dental groove had approached so as to require separation by the needle to exhibit its contents distinctly. The papilla (1 or 2, Fig. 9,) had undergone little change,

but two very indistinct bulgings (3 and 4,) had appeared on each side of the labial frenum, the centrals being the largest.—The breadth of the superior arch was $1\frac{2}{3}$ line ; the length $1\frac{1}{3}$ line.

Fig. 9.



5.—In an embryo of the tenth week the following appearances presented themselves.

Upper Jaw.—Very little change had taken place in the lateral lobules (*n n*, Fig. 10,) or the median (*m*,) and its additional lobule (*y*). They had all increased absolutely, and if any relative change had taken place, it was in the transverse diminution of the median (*m*,) and the movement forward of its additional lobule (*y*). The palate had advanced anteriorly, so as not only to have encroached in some degree upon the median and lateral lobule, but also to have thrown itself into folds immediately behind them. The outline of the horse-shoe lobe (which is represented in the sketch as turned aside to exhibit the dental groove) was still observed. There was an indistinct uvula. The papilla (1 and 2) had sunk completely into follicles, and could only be seen by looking into the open mouths of the latter. The mouth of (1) was bordered by four laminæ or lids, that of (2,) by three, as represented in the sketch. The papillæ (3 and 4) had not increased much, but their notched laminæ had become more distinct. At the posterior extremity of the floor of the dental groove on the inner side of the lobule (*q*, Fig. 4, 6, 8, 10,) a slight bulging (5, Fig. 10,) was seen.

Fig. 10.

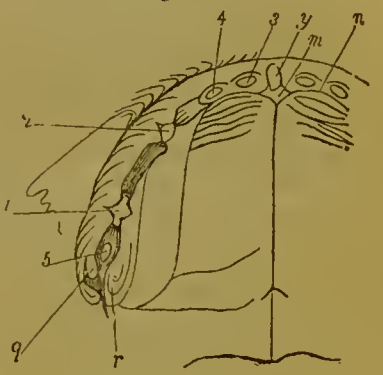
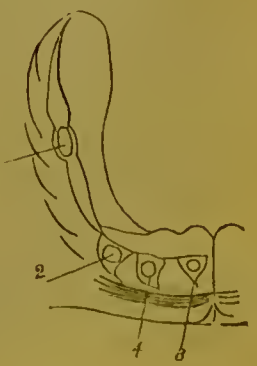


Fig. 11.



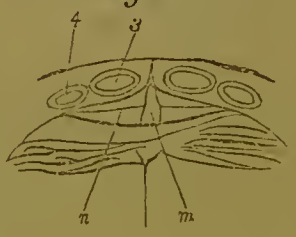
The upper lip had receded in the neighbourhood of the median line, so as to have disappeared almost entirely at that spot, the centre of the upper dental arch being exposed.

Lower Jaw.—The bulgings on each side of the median line (3, 4, Fig. 11,) which were so indistinct in the last subject, had become well developed, and inclosed in follicles, through the mouths of which they were seen. A similar change

was observed in reference to the papilla (2). The follicles had been produced, by the stretching across of productions from the outer lip, (which was very indistinct,) towards similar but much smaller productions from the inner lip, (which was still very prominent.) The lines of junction of the septa were visible, and the mouths of the follicles presented an unfinished appearance. The papilla (1) had become surrounded by an incomplete follicle, in consequence of the production of a notched lamina from the outer lip of the groove, which lamina was almost met by a smaller slip of membrane from the inner lip.—The breadth of the superior arch was 2 lines, length $1\frac{2}{3}$ line.

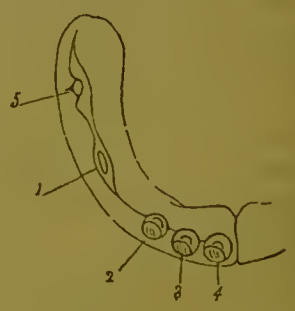
6.—11*th* or 12*th week.*—*Upper Jaw.*—The median lobule (*m*, Fig. 12,) had diminished so much transversely, as to have become antero-posterior; while its supplementary lobule had become attached to the frenum of the lip. The lateral lobules (*u u*) had increased much transversely, and appeared each to be divided into an anterior and a posterior portion. They were compressed by the true palate, which was folded at this part as at the tenth week into wrinkles, the longest and anterior of which, stretched across the median line from the right to the left side. The papillæ (3 and 4) with their follicles were fully developed. The other two papillæ (1 and 2, Fig. 10,) had not undergone much change, but the small bulging (5, Fig. 10,) had now become a distinct papilla, and its follicle had begun to show itself. The uvula was well marked.

Fig. 12.



Lower Jaw—The lines of junction of the interfollicular septa had almost disappeared, and the mouths of the follicles had become more distinct. The mouths of the three anterior follicles had an anterior lip, the free edge of which was directed somewhat inwards. It was necessary to lift up this lip with the needle to obtain a view of the contained papilla. At the posterior part of the dental groove, another papilla with a notched lamina, both productions from the external lip, had appeared (5, Fig. 13).—Breadth of superior arch $12\frac{1}{2}$ lines; length, 2.

Fig. 13.

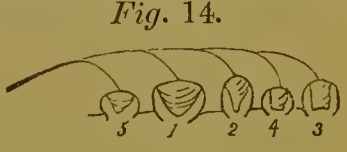


7.—13*th week.*—*Upper Jaw.*—There was little change in the configuration of the palate since the former week. The lobe running across the median line was still visible. The frenum of

the upper lip had become closely attached to, and continuous with, the median lobule. The outlines of the horse-shoe lobe were still perceptible, and on its external side the lobule, all along marked (*r*,) was visible. The outer lip of the dental groove, or the external alveolar process, was equally developed all around. The upper lip was still much retracted. There were ten papillæ, inclosed in open-mouthed follicles, and ranged at nearly equal distances all around the dental groove. * The four anterior papillæ were flattened from before backwards with a straight edge, and were somewhat similar to the future incisive teeth. The next one on each side was a simple cone. The two posterior on each side were also conical, but flattened transversely, so as considerably to resemble carnivorous molars. Each of these papillæ adhered by its base to the fundus, while its apex, as during the eleventh and twelfth weeks, presented itself at, or, as in the present instance, protruded from, the mouth of its follicle. The point of the needle could be introduced through the mouth, so as to move the papilla about in the interior of the follicle.

By removing the outer lip of the dental groove, and the outer wall of all the follicles by the scissors, a good view was obtained of the configuration of these parts (Fig. 14). The follicles were observed to be mere duplications of the membrane of the groove, and consequently of the *general gastro-intestinal mucous membrane.* The inner surface of the follicles was of a greyish-yellow colour. The papillæ had increased relatively so as to protrude from the mouths of their follicles. They were granular, friable, and of a dead-white colour.

Fig. 14.



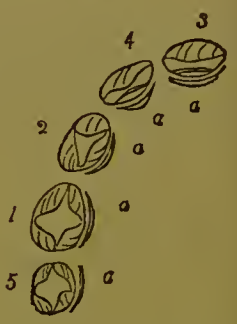
Lower Jaw.—No remarkable change had taken place in the lower jaw, except in the relative enlargement of the papillæ, and in the distinct developement of the follicle of the posterior papilla (5, Fig. 13). The outer lip of the dental groove was not very distinctly marked, but the inner was well developed.—The breadth of the superior arch was 3 lines, and the length was also 3 lines.

8.—14*th Week.*—*Upper Jaw.*—The median lobule had undergone little change, the lateral lobules had become broader from before backwards, apparently in consequence of the retraction of the palate, which, instead of exhibiting on its anterior part the confused transverse wrinkles formerly mentioned, presented on its lateral divisions, (corresponding to the horse-shoe lobe,) four or five parallel rugæ, which were apparently remains of the wrinkles. The

* Arnold, Salzburg Med. Chirurg. Zeitung 1831. Erster Band, p. 236. Valentin, Handbuch der Entwickelungs-geschichte des Menschen, p. 482.

upper lip had again become full, so that its free edge was on a level with the surface of the palate. The soft outer edges of the palate and the anterior edges of the lateral lobules were now closely applied to the outer lip of the dental groove, so as to close the latter in a valvular manner. When these edges, viz. the continuous semicircular outline of the whole palate, were raised by the needle, the dental groove with its contents, viz. ten papillæ in their follicles, were seen. It was observed that the follicles had increased relatively, the papillæ only absolutely, in consequence of which the latter, instead of projecting from, had receded within, the mouths of the former. The mouths of the follicles had apparently become smaller. This had arisen in consequence of the greater developement of the laminæ which were seen in the earlier stages. There were two, an anterior and a posterior, for the four anterior follicles, three, an internal and two external for the third, on each side, and four for the two posterior on each side. (Fig. 15.) Close upon the inner side of the mouth of each of the follicles there was observed a little depression in the form of a crescent, its concave edge being towards the former. These depressions were most distinctly marked at the four or six anterior follicles, where they were situated immediately behind their inner lips, (*a a a a a.*)

Fig. 15.



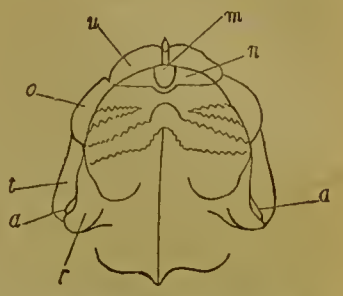
Lower Jaw.—The papilla had receded. The laminæ of the follicles were more developed. (Fig. 16). Little depressions or lunulæ had appeared similar to those in the upper jaw. When the membrane of the dental groove, with its adherent follicles and their pulps, was stripped off, the dental nerves and vessels were found running along under the follicles, and distributing vascular branches, and a nervous twig to each of them. (Fig. 14). Each of the individual follicles with its papilla, vascular branches, and nervous twig exactly resembled a large hair bulb with its nerve and vessels exposed after the hair has been extracted.—Breadth of the superior arch, $3\frac{1}{2}$ lines; length, 3 lines.

Fig. 16.

9.—15*th Week.*—*Upper Jaw.*—The outer edges of the palate, which in the last embryo lay unattached on the outer lip of the dental groove, in the present subject adhered firmly to it, except along a small portion posteriorly. (*a*, Fig. 17.) This

adhesion was firm anteriorly on both sides of the median line, then became weaker, and posteriorly at the non-adherent portion (*a*,) between the lobules (*r* and *t*,) the lips of the groove retained their original smooth edges. When the lips of this non-adherent portion were separated by the needles, its floor and walls exhibited nothing but the greyish-yellow mucous membrane of the original groove. The outer lip of the dental groove was visible all around the external margin of the palate, and was divided on both sides into three parts, an anterior (*u*), a lateral (*o*), and a posterior (*t*). On the inner side of the latter was seen the longitudinal lobule, which has hitherto been marked (*r*). The median lobule (*m*) was rounded anteriorly, and had a process (*y*, Figs. 8 and 10,) which stretched forwards between the lobules (*a a*). This was the additional lobule formerly mentioned. The sides of the median lobule were straight and converged to its posterior extremity, which was circular, and was received into a curve, in the middle of a transverse band, constituting the anterior boundary of the palate, which appeared to have receded still more than in the last subject, and to have exposed still more completely the lateral lobules (*n n*). The four rugæ seen in the last subject had become ridges beautifully crenated, and converging, as represented in the sketch, towards a curve, reversed and opposite to the one formerly mentioned in the middle of the transverse band of the palate. This last curve was the result of the anterior junction of the lobes, (*d d*, Fig. 2,) and was traced through all its phases to its present state. The median suture of the palate proceeded from it posteriorly. The dental groove being torn open by means of the needles, its lips were found to have adhered pretty firmly, as before-mentioned, but a feeble adhesion only had taken place between its walls, so as to allow its contents to be restored to their original condition by means of a blunt instrument. This was carefully done under water, and the mouths of all the follicles with their laminæ were displayed. The latter were more developed than in the last subject, and completely concealed the papilla. The former required to be lifted up in order to display the latter. Careful observation during the separation of the contents of the groove disclosed the important fact, that the general adhesion had not obliterated the little crescent-shaped depressions behind the mouths of the follicles. These retained the smooth greyish-yellow colour of the walls of the original groove, and from this circumstance could be distinguished from the general flocculent appearance of the other parts.

Fig. 17.



Lower Jaw.—The outer lip of the dental groove had increas-

ed in size, and was as prominent as the inner, except posteriorly, where the latter still retained its posterior lobe; but the most remarkable change which had taken place since last week was the complete adhesion of both lips, as in the upper jaw, with the exception of a small portion posteriorly, which still retained the peculiar appearance of the dental groove, and in which nothing could be seen but the smooth mucous membrane; (*a*, Fig. 18.) When the dental groove was torn open, as was done in the upper jaw, the laminæ (which were highly developed) of the follicles, and the walls of the groove, were found to be rough and flocculent from adhesions, with the exception of the little depressions formerly mentioned, which still retained their original appearance.

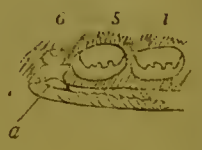
Fig. 18.

Breadth of the superior arch, 5 lines; length, 4 lines.

10.—16*th week.* — *Upper Jaw.*—The palate retained the appearance it had in the last subject, with the exception of the median lobule, which had become narrow in front, and broad posteriorly. The raphe of the dental groove had become firmer, so as to give a much more defined and permanent appearance to the non-adherent portion posteriorly, which was now seen to great advantage, its fine greyish mucous membrane gradually running at its edges into the white tough substance of the palate and gums.

Having separated the lips of the non-adherent portion (*a*, Fig. 19,) a papilla, sunk in an open follicle, with three or four laminæ, was visible, (*b*.) The membrane of the palate and maxillary arch being stripped from the bone, and its surface of adhesion examined, lines corresponding with the sutures of the bones were observed; one the median, another the intermaxillary, and a third with the palato-maxillary. Five tooth sacs were also observed on both sides of the maxillary arch. These were divided into three groups, two in the first, or anterior, one in the second, and two in the third, or posterior. These groups were covered with a flocculent spongy membrane, which was easily stripped off by the forceps, and when this was carefully done, it became evident that the sacs which were formerly grouped together by this membrane were individually isolated, and formed of a thin gray diaphanous membrane, similar to the one formerly mentioned as covering the bottom of the dental groove, and constituting the membrane of the follicles. The careful detachment of the external

Fig. 19.



spongy membrane from the posterior group showed, what was not at first observed, that there was at the posterior part of the posterior sac another very small one, which by careful examination was seen to be the fundus of the open follicle in the non-adherent portion of the dental groove.

The adhesion of the lip and walls of the groove had now become so strong, that it was impossible to separate them. The only way, therefore, in which its contents could be examined was by transverse sections. When these sections were made between the different sacs, they displayed scarcely any traces of the dental groove; but when they passed through any place perpendicular to the surface of the gum, and near to the middle of any of the sacs, they exhibited the appearances represented in the marginal sketch, (Fig. 20.) The deciduous tooth pulp, (*a*,) which was lately a free papilla; (*b*,) the section of its sac, which was a follicle when the pulp was a papilla; (*d*,) the line of adhesion of part of the walls of the dental groove leading from the shut sac to (*c*,) the raphe of the groove; (*e*,) the section of the non-adherent portion of the groove in the situation of the lunula, which existed behind (*f*,) the inner laminæ of the sac (*b*,) in its former follicular condition. From the consideration of this section, (Fig. 20,) the mode in which the original follicle, the non-adherent depression behind the inner laminæ, and the walls of the dental groove, were connected after full adhesion of all the neighbouring parts, will be easily understood. The little cavity (*e*) adhered by its anterior and inferior extremity to the line of adhesion, (*d*,) so that it and the sac of the milk tooth were both connected to the raphe of the edges of the dental grooves by lines of attachment, which resembled two petioles proceeding from a common footstalk. These lines of attachment were not tubular, but resisted all efforts to push a fine probe or bristle through them: they were merely opaque remains of the surfaces of junction contrasting with the semitransparent substance of the gums. Parallel sections through all the sacs exhibited similar appearances. When the contents of the sacs were examined, the pulps were found to have acquired the configuration of the bodies of the future teeth. The bases by which the molar pulps formerly adhered to the bottoms of their sacs, and which may be denominated their primary bases, had become almost divided into three secondary bases, which corresponded with the internal and two external fangs of the future teeth. This division was so far accomplished by the advancement of the internal grey membrane of the sac, under the form of small compressed canals between the base of the pulp and the external spongy membrane. These canals, which were three in number, one external

Fig. 20.

and two internal, did not meet in the middle under the pulp. Deposition of *tooth substance* (Zahn-substanz) had commenced on the edges and tubercles.

The sacs were twice as large as their contained pulps, and in the space (*g*, Fig. 20,) which existed between them, there was observed a very soft flocculent gelatinous substance, which had no attachment to the pulp, and did not appear to adhere to any part of the sacs, except the laminæ, and the parts adjoining them.

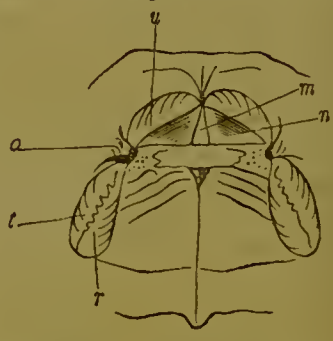
Lower Jaw.—The adhesion of the dental groove was not so strong as in the upper jaw. The open portion (*a*, Fig. 18,) was fully defined, and exhibited on its floor the orifice of a follicle, containing a papilla. In other respects the lower was similar to the upper-jaw.

Breadth of superior arch 7 lines; length 5 lines.

11.—*5th month.*—Fœtus minutely injected with size and vermilion.

Upper Jaw.—The lobes (*t*, *o*, *u*, Fig. 21,) had become highly developed. The anterior one (*u*) was convex anteriorly, with a sharp edge directed backwards, and corresponded with the incisive teeth. The central lobe (*o*) had become shorter, but more prominent, like a canine tooth. The posterior (*t*) had united firmly with the longitudinal lobe all along marked (*r*,) so as to close the open portion of the groove (*a*, Fig. 17,) which was described in the two last subjects. The raphe of the groove between these two lobes was serrated, and a vessel was seen traversing each denticulation. The raphe then ran close along the inner edges of the bases of the lobes, (*o* and *u*.) The median lobule was triangular, the base posterior; the apex in front continuous with the labial frenum, and situated between the anterior pointed extremities of the lobules, (*u*, *u*.) The lateral lobules were very distinct. The other less important changes which had taken place in the palate may be understood by comparing Figs. 21 and 17.

Fig. 21.



The membrane of the palate with the sacs of the teeth were removed from the bone. The fundus of the follicle (6, Fig. 19,) had now assumed the appearance of a sac, and the other ten, instead of being grouped, had become isolated. The branch of the dental artery, which supplied each of the sacs and their pulps, was seen when it reached the fundus of the former to give off a number of twigs, which, radiating from their common centre, proceeded perpendicularly towards the gum, near which they inosculated with

others proceeding from it. The combined vessels then formed a pretty minute net-work in the spongy membrane formerly described.

Transverse sections were now made by the scissors through all the sacs. The general appearance of these sections was similar to that of those at the 4th month, but the gelatinous granular substance between the pulp and the sac was of the consistence of very firm jelly, closely and intimately adherent to the whole interior of the sac, with the exception of a narrow strip all around the base of the pulp, along which strip, the grey membrane of the sac retained its original appearance, and through which the radiating saccular twigs were visible, being strongly and beautifully contrasted with the cream-coloured surface of the granular substance. The mass of the granular substance had a peculiar greyish white colour, its surface was cream-coloured, and had a dry chalky appearance. It had a tendency to tear in a direction perpendicular to the internal surface of the sac. Although closely applied it did not adhere to the pulp, but, as stated above, surrounded it on all sides till within a short distance of its base—" whatever eminences or cavities the one *had*, the other *had* the same, but reversed, so that they *were* moulded exactly to each other." In the incisives its principal mass lay—" against the hollowed inside of the tooth, and in the molars, it *was* placed directly against their base like a tooth of the opposite jaw." In the pulps of the molars, which had three canals which *now* passed completely across their bases, the granular substance sent a process into each of them. These processes did not meet in the centre, but disappeared near to it, and left, as in the case of the general mass, a minute portion of the grey membrane of the sac, between themselves and the secondary bases of the pulp.* In the case of the molars also the dental arterial branch divided into three twigs, one for each secondary base of the pulp, and from all of these, radiating perpen-

* The only authors, as far as I know, who have observed and described this gelatinous body, are Mr Hunter in his Natural History of the Teeth, p. 94, and Purkinje and Raschkow, in the work of the latter, entitled, " Meletemata circa Mammalium dentium evolutionem"—Not having been able, hitherto, to procure Raschkow's work, I can only state from Burdach (Physiologie, French ed. Tom. iii. p. 498), that Purkinje's opinion appears to coincide with Mr Hunter's as to its being the organ which secretes that enamel. Mr Hunter has not described the processes which this body sends under the pulp, or the space left between it and the base of the latter, but his description is in other respects so correct and characteristic that it is difficult to account for the manner in which the first part of his chapter on the formation of the enamel has been so much misunderstood. Dr Blake (p. 34,) (although he described the granular body as the inner membrane of the tooth sacs, and as possessing " no vessels capable of conveying red blood) supposed that Mr Hunter meant by " another pulpy substance," the sacs of the permanent teeth. Mr Bell also in a note, Vol. ii. Palmer's ed. Hunter's works, p. 43, states that after most accurate observations, he had come to the conclusion that the " pulpy substance" mentioned by Hunter, is nothing more than the inner membrane of the sac turgid with blood and earthy matter preparatory to the secretion of the enamel.

dicular ramuscules proceeded as in the case of a pulp with a primary base.

The arterial net-work, which was formed in the external spongy membrane by the inosculation of these vessels with those proceeding from the gums, transmitted small branches which ramified with such minuteness in the substance, and on the surface of that portion of the gray membrane to which the granular matter adhered, that, when the latter was removed, the former appeared to the naked eye a mass of vermilion, but under a one-fourth of an inch lens exhibited a net-work of the most minute injection. No injected vessel could be seen in the granular substance.* The main dental twig after giving off all these branches, arrived at the base or secondary bases of the pulp, and immediately divided into many branches, which ramified in a contorted flattened position, between the base or bases of the pulp and the membrane of the sac. From these, smaller ramifications were transmitted into the substance of the pulp, which ramified in considerable numbers in the centre of its mass, but scarcely at all near its surface or on its membrane, except in the neighbourhood of, and at the point where, deposition of *tooth substance* had commenced, immediately beneath which the vascularity was intense, both in the substance under, and on the surface a little beyond, the edge of the scale.† This surrounding vascularity had the appearance of a zone, and was situated in the substance, and on the surface of an elevated portion of the pulp, which surrounded the scale of tooth substance.

The granular substance in contact with the tooth substance and its border had begun to be absorbed, and had consequently become thinner in that situation than elsewhere, allowing the subjacent vascularity to appear through it. No vessel could be detected in the granular substance to account for the absorption of its inner surface.

The ten little cavities had undergone no change, except that the two or four anterior had become rather longer, and were situated farther from the surface of the groove, so as to be placed rather behind than below the sacs. The anterior cavity, in particular, although its walls were still in contact, and required to be separated by the needles under water to see its interior, had become pear-shaped. The fundus or portion farthest from the gum exhibited on its floor a fold, which lay in the direction of the edge of the future permanent tooth, and near its apex there were two other minute folds, one on the anterior wall, the other on the posterior. Beyond this the cavity terminated in an opaque IMPERVIOUS line, which soon disappeared. The substance of the gums had become infiltrated with a quantity of gelatinous matter

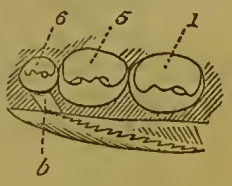
* Blake, Essay on the Structure and formation of the Teeth, p. 4.

† Serres, Essai sur l'Anatomie et la Physiologie des Dents, p. 20.

very similar to the granular substance of the sacs. In consequence of this infiltration the line of junction of the walls of the dental groove had become obliterated, the substances of the gums had become thicker, and the sacs more removed from the surface.

The open portion of the groove (*a*, Fig, 19,) had disappeared, but a longitudinal section showed that the *lips* only had adhered, the *walls* had not. The follicle (6, Fig. 22,) had become a sac, in consequence of which a cavity (*b*) remained between it and the surface of the gum. Gelatinous substance had been deposited in the sac (6), and in the neighbourhood of the cavity below it (*b*), as in the other sacs.

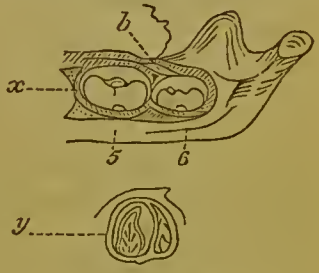
Fig. 22.



The lower jaw exhibited changes analogous to those in the upper.

12.—*Child at Birth*—A longitudinal section was made through the posterior part of the under jaw, when the sacs and pulps of the posterior milk molar, and of the first permanent molar, and the arrangements represented in Fig. 23 were observed. (5,) the sac and pulp of the posterior milk molar; (6,) the sac and pulp of the first permanent molar; (*b*) the cavity marked (*b*, Fig. 22).

Fig. 23.



The sac of the permanent tooth (6) was now almost wholly imbedded in the base of the coronoid process of the jaw. The cavity (*b*,) which was attached to the upper part of the sac of the permanent tooth by its posterior extremity, adhered by its anterior extremity, to that point of the gum which was attached to the anterior edge of the base of the coronoid process, so as to drag its surface at that point into a dimple. The cavity (*b*) was consequently longer than it was at its first formation.

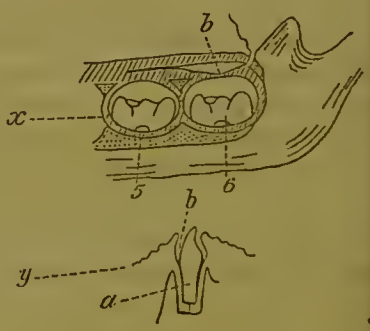
The granular substance had wholly disappeared. The interior of the sacs had a villous highly vascular appearance, like a portion of injected intestinal mucous membrane. The original opening of the sac (6) into the cavity (*b*) was indicated on its inner surface by an indistinct circular lip. The sacs of one of the central incisives of the same fœtus exhibited externally nothing peculiar. After a transverse section, it was found to be composed of two, the temporary and permanent combined.

The walls of the temporary sac (*b*, Fig. 23,) were composed of an external membrane, which was rather thick and condensed;

the inner could be separated from it, and had the appearance, as in the molar sacs, of an injected villous membrane. The little permanent sac was situated in the substance of the outer membrane of the temporary sac, as if the latter had been split to receive it. It was lined by a membrane similar to that of the temporary, and exhibited near the lower end of its posterior wall the incipient pulp, which was evidently a developement of the fold observed in that situation at the fifth month. It terminated towards the gum by an indistinct pointed extremity, from which a short opaque impervious line proceeded, near to which the anterior and posterior folds, observed at the five month, were seen.

13.—The lower jaw of an infant about eight or nine months old, in which the central incisives had cut the gum, was prepared by removing a section from its external posterior lateral aspect, so as to expose the sacs of the posterior milk molar, and of the anterior permanent molar (*x*, Fig. 24). The latter (6,) instead of being buried in the base of the coronoid process, was situated further forward and the cavity (*b*,) having been displayed by a longitudinal section of the former, was found, comparatively speaking, to have recovered its original small extent, being attached inferiorly to the top of the sac (6), and superiorly to the anterior edge of the base of the coronoid process.

Fig. 24.



Upon examining the two incisive teeth which had cut the gum, it was found that a bristle could be inserted between their surfaces and the gum, for one-third of an inch. Through the soft parts a transverse section was made, which was afterwards continued through the jaw and one of the teeth by means of a very fine saw.

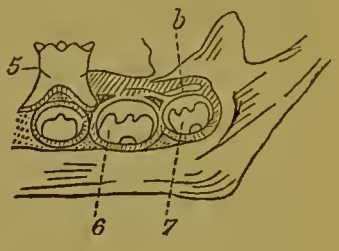
It was now observed that the tooth (*a*, Fig. 24 *y*,) had acquired nearly two-thirds of its fang, and that the *sac* had again become an open follicle (*b*). This follicle was shorter than the whole length of the tooth by the length of the protruding portion of the latter. At the mouth of the follicle, its lining membrane was continuous with the surface of the gums, and continued free till it arrived at the termination of the enamel, where it united to the surface of the fang of the tooth, but could be separated from it as a continuous membrane, and at the lower end of the root it became continuous with the surface of the pulp, whose base was yet considerable. Upon removing the bone in front of the neighbouring lateral tooth, which had not yet passed through the gum, it was observed that the extremity of its fang, or rather the fundus of its sac, was

deeper in the jaw than that of the central, by a length equal to the protruding portion of the latter. This change of level had not, however, taken place in the case of the alveoli, that of the central being rather deeper than the lateral. The space intervening between the bottom of the alveolus of the central tooth, and the fundus of its sac, was occupied by a spongy filamentous tissue, through which the dental vessels and nerves proceeded.

14.—The lower jaw of an infant, which had cut all its milk teeth, and which was probably between four and five years old, was prepared in the same manner as the last.

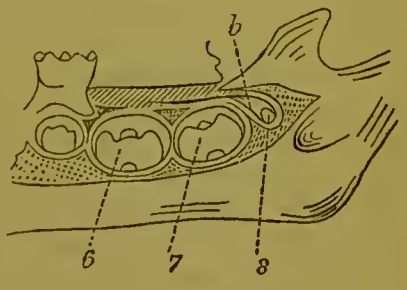
The sac of the anterior permanent molar (6, Fig. 25,) was situated under the gum in front of the coronoid process, and a new sac and pulp of a smaller size (7,) had appeared buried in the base of that process. The cavity (*b*) was again lengthened out, being attached anteriorly, at the anterior edge of the base of the process, to the gum, and posteriorly to the top of the new sac (7.) That portion of the cavity formerly attached to the sac (6,) was now almost obliterated.

Fig. 25.



15.—The posterior part of the lower jaw of a child about six years old was prepared by removing a section from its internal posterior aspect, and making at the same time a longitudinal section of the gum. The sac (7, Fig. 26,) had advanced from under the coronoid process; and another very small sac and pulp had appeared inclosed in a bony crypt under the process, and communicating through the upper part of the bony cell of the sac (7,) with the gum, where it terminated in an opaque line or tail, the last remains of the surface of adhesion of the dental groove.

Fig 26.



SECTION II.—A DESCRIPTION OF THE PULPS AND SACS FROM THEIR FIRST APPEARANCE IN THE EMBRYO TILL THE ERUPTION OF THE WISDOM TEETH.

When we examine the upper jaw of a human embryo at the sixth week, there is perceived between the lip and a semicircular lobe of a horse-shoe form, (which is the primitive condition of the palate) a deep narrow groove which terminates on each

side, behind the former, by curving inwards on the soft mucous membrane. As this groove becomes gradually wider, and the lip more lax in a direction from behind forwards, there appears on its floor posteriorly, and proceeding in the same direction, a ridge (the external alveolar process,) which speedily divides the original groove into two others; the outer one, forming the duplicature of mucous membrane from the inside of the lip to the outside of the alveolar process, the inner one, constituting what may be very properly denominated the *primitive dental groove*, as the germs of the teeth appear in it.

The inner side of the ridge already mentioned, after being cut into three grooves whose concavities look inwards, and of which the posterior is the deepest, terminates in a rounded lobule, which is continuous with it anteriorly, while externally, internally, and posteriorly, it is bounded by that portion of the original groove which was situated behind the semicircular lobe. The curves of the ridge are occupied by bulgings of the semicircular lobe, so that the ridge and lobe with their curves and bulgings, are exactly similar to the arrangement of the mucous membrane of the second compartment of the stomach of the porpoise.

At some period between the sixth and seventh week a longitudinal portion is cut off, from the internal posterior edge of the semicircular lobe, extending as far forwards as the middle bulging, and about the same time the posterior bulging becomes isolated, and defined, under the appearance of an ovoidal papilla, the long diameter of which is antero-posterior. This papilla is the germ of the anterior superior milk molar tooth, the first tooth germ which appears in the developement of the human body. It is at this period a simple free granular papilla, like many others on the surface of the mucous membrane and skin.

About the eighth week or second month, a second papilla appears at the point of projection of the ridge, between the middle and anterior curve. This papilla, which is the germ of the superior milk canine tooth, is rounded and granular, and is bounded externally by a triangular lamina, which spreads out into, and is continuous with, the inner edge of the ridge, having its apex notched so as to fit the external aspect of the papilla.

During the ninth week the ridge advances in an indistinct manner to the median line, and there appears on each side of that line an oblong papilla with a notched lamina in front of it, and immediately afterwards another smaller papilla and lamina external to the former. These last papillæ are the germs of the incisive teeth, and are placed in connection with the lateral elements of the inter-maxillary system.

The primitive dental groove, which before the appearance of the incisive germs terminated anteriorly at the outer extremity of the lateral inter-maxillary lobules, now extends forwards to the

median line. The longitudinal lobule, and the lobule opposite to it also, have lengthened out posteriorly, and the intervening portion of the primitive groove has become wider and not so curved. The sides of the groove before and behind the anterior molar papilla have been gradully approaching one another.

During the tenth week, the incisive papillæ make very little advance, their anterior laminæ only increasing somewhat in size. Processes from the sides of the primitive dental groove, particularly the external one, approach and finally meet before and behind the papilla of the anterior molar, so as to inclose it in a follicle through the mouth of which it may be seen. A similar follicle is gradually formed round the canine by the advancement inwards of its external notched lamina, which at first appeared as a production of the ridge or external lip of the groove. The germ of the posterior milk molar also appears as a small papilla towards the end of this week behind the anterior molar, at the side and apparently as a production from the rounded lobule, which terminates posteriorly the outer ridge.

During the eleventh and twefth week, the incisives advance steadily. Septa pass between them from the outer to the inner side of the groove, so that their papillæ become completely sunk in well developed follicles. No material change takes place in the anterior molar or canine, but the posterior molar papilla enlarges, and the terminal lobule of the outer ridge folds gradually round it, so as to constitute its follicle, behind which there still remains a portion of the primitive groove.

The changes which ensue during the thirteenth week consist in the completion of the follicle of the posterior molar, and in the gradual change which takes place in the shape of the different papillæ. Instead of remaining, as hitherto, simple, rounded, blunt masses of granular matter, each of them assumes a particular shape. The incisives acquire in some degree the appearance of the future teeth; the canines become simple cones; and the molars become cones flattened transversely, somewhat similar to carnivorous molars. During this period, too, the papillæ grow faster than the follicles, so that the former protrude from the mouth of the latter, while the depth of the latter varies directly as the length of the fangs of their future corresponding teeth, the canine follicle being deepest, &c. &c. While the papillæ are changing their shape, the mouths of the follicles are undergoing a change which consists in the developement of their edges, so as to form opercula, which correspond in some measure with the shape of the crowns of the future teeth. There are two of these opercula in the incisive follicles, one larger, anterior, and rather external, the second smaller, posterior, and internal. There are three for the canines, an external and two internal, and four or five for the molars, each cor-

responding with a tubercle; while their edges correspond with the grooves on the grinding surfaces of these teeth.*

The inner lip of the dental groove (or the outer edge of the palate) which has been increasing for some time past, is now at the fourteenth week, so large as to meet and to apply itself in a valvular manner to the outer lip or ridge, which has also been increasing, The follicles at this time grow faster than the papillæ, so that the latter recede into the former. The molar papillæ gradually acquire two or three additional small compressed tubercles on their sides, and their apices become less conical, so that they still more resemble the molar teeth of the carnivorous mammals.† The opercula of the follicles continue to increase, so as almost to hide their contained papillæ.

The *primitive dental groove*, which at this period contains ten papillæ in as many follicles, and is situated on a higher level than at first, may be now more properly denominated the *secondary dental groove*. It is when in its secondary condition that the groove affords a provision for the production of all the permanent teeth, with the exception of the first or anterior molars. It is about the fourteenth or fifteenth week that we begin to observe preparations made for this provision, by the gradual appearance of a little depression in the form of a crescent, immediately behind the inner opercula of each of the milk tooth follicles. The concave edges of these depressions are in contact with the attached margins of these opercula. Those of the centre incisives appear first, then the laterals, canines, anterior bicuspids, posterior bicuspids. About this time the opercula close the mouths of the follicles, but without adhering, then the anterior closing first, the laterals, and so on in succession. The lips and walls of the secondary groove now begin to cohere in a direction from behind forwards, the opercula and every part of the groove, with the exception of the ten depressions for the permanent teeth, becoming rough, flocculent, and adherent. The follicles have now become the *sacs;* the papillæ

* It would be interesting to ascertain whether the opercula of the human tooth follicles may not be rudimentary organs, which are to attain their utmost developement in the sacs of the elephantoid, ruminant, and other compound teeth, under the form of depending folds for the secretion of the intersecting enamel and cement plates.

One may easily conceive the mode of formation of a composite tooth sac, by supposing the opercula, after their edges have met, to dip down back to back between the divisions of the pulp, till they almost meet the common body of the latter.

† This is another instance of the law of progressive developement, by virtue of which an organ, in the course of its formation, passes through phases, which correspond to permanent conditions of the same organ in other animals. A human molar tooth pulp is at first rounded, as in certain fishes; then conical, as in other fishes and reptiles; then conical, but flattened transversely, gradually acquiring two or more additional conical tubercles, as in the carnivorous mammals; and finally, by the equalization of the primary and secondary tubercles, asssuming the shape of the molars in the quadrumanous animals and man. In the elephantoid, ruminant, and rodent animals, it probably undergoes a further and ultimate change in the deepening of the rudimentary grooves on the grinding surface.

the *pulps* of the milk teeth ; and the crescent-formed depressions vacant *cavities of reserve*, to furnish delicate mucous membrane for the future formation of the *pulps* and *sacs* of the *ten* anterior permanent teeth.

The general adhesion does not invade that portion of the primitive dental groove which is situated behind the posterior milk molar follicle. This small portion retains its original appearance, greyish-yellow colour, and smooth edges for a fortnight or three weeks longer, and affords a nidus for the developement of the papilla and follicle of the anterior permanent molar tooth, the fundus of its follicle being situated immediately behind the sac of the posterior milk molar. The *cavities of reserve* for the ten anterior permanent teeth are at this period minute compressed sacs, with their sides in contact, and situated between the surface of the gum and the milk sacs.

The papillæ of the milk teeth, from the time that their follicles close,* become gradually moulded into their peculiarly human shape. The molar pulps begin to be perforated also by three canals which, proceeding from the surface to their centres, gradually divide their primary base into three secondary bases, which become developed into the fangs of the future teeth. While this is going on, the sacs grow more rapidly than the pulps, so that there speedily exists an intervening space, in which is deposited a gelatinous granular substance, at first in small quantity, and adherent only to the proximal surfaces of the sacs, but ultimately about the fifth month, closely and intimately attached to the whole interior of these organs, except for a small space of equal breadth, all round the base of the pulp, which space retains the original grey colour of the inner membrane of the follicle, and as the primary base of the pulp becomes perforated by the canals formerly mentioned, the granular matter sends processes into them, which, adhering to the sac, reserve the narrow space described above between themselves and the secondary bases. These processes of granular matter do not meet across the canals, but disappear near their point of junction. The granular matter is closely applied, but does not adhere to the surface of the pulp. "Whatever eminences or cavities the one has, the other has the same but reversed, so that they are moulded exactly to each other."

Each branch of the dental artery, as it arrives at the fundus of

---

* Herissant in the "Mem. de l'Acadamie Royale," 1754, p. 664, described two gums. the "gencive permanent" and the "gencive passagere." His ideas on the subject appear to have been derived from the examination of jaws in which the lips and walls of the secondary dental groove "gencive passagere," had not become completely adherent or obliterated. In this way the indistinct mouths of the milk tooth sacs on the floor of the groove "gencive permanent," did not escape the notice of this most accurate observer. The cartilages of the gum described by Serres, Essai, p. 10, are to be considered as the walls of the groove in the semicartilaginous condition which they assume after closure.

its destined sac, sends off a number of radiating twigs, which run in the substance of the cellular submucous tissue (which constitutes the outer membrane of the sac) towards the gum, from which others proceed to inosculate with them. The combined twigs then ramify minutely in the true membrane of the sac, without sending the smallest twig into the granular substance.* The dental branch, after giving off these saccular twigs, divides into a number of contorted ramifications between the base of the pulp and the sac, which from smaller ramusculi are transmitted into the pulp itself. In the case of the molars, the main branches divide into three secondary branches, one for each of the secondary bases. From these, three sets of saccular twigs, and three packets of contorted pulp vessels, take their origin.

While these changes have been taking place in the sacs of the milk teeth, the follicle of the first permanent molar closes, and granular matter is deposited in its sac. The walls of that portion of the secondary groove below it do not adhere; the edges alone do so. There is, therefore, a cavity of considerable size below the sac of this tooth, or between it and the surface of the gum. This cavity is a reserve of delicate mucous membrane to afford materials for the formation of the second permanent molar, and of the third permanent molar or wisdom tooth.

A little before this period, *tooth substance* begins to be deposited on the tubercles and apices of the pulps, which have acquired round the point of deposition a raised border and a zone-like vascularity; and synchronous with this deposition, absorption takes place on the inner surface of the granular matter immediately in contact with it. No vessel can be detected running to the point of absorption, but ultimately the granular matter becomes so thin as to allow the subjacent vascularity to appear. The absorption goes on increasing as the tooth substance is deposited, and when

* Mr Fox (Natural History of the Human Teeth, p. 20.) and Mr Bell (Anatomy of the Teeth, p. 54, and in a note, p. 39, Vol. ii. Palmer's edition of Hunter's Works,) have both misunderstood the statements of Mr Hunter and Dr Blake on the relative vascularity of the membranes of the tooth sacs. (Hunter's Natural History, p. 84, and Blake, p. 4.) What Blake denominates the internal lamella, is the enamel pulp of Hunter, Purkinje, and Raschkow, the gelatinous granular substance described in the text. He with great accuracy states, that it is "more tender and delicate, and seems to contain no vessels capable of conveying red blood." Under the denomination "external lamella" he includes the proper vascular mucous membrane of the sac, and the external spongy submucous tissue. In his search after the germs of the permanent teeth, Blake's attention appears to have been directed to the tooth sacs when in the condition he describes. Mr Hunter, again, who had a most correct conception of the constitution of the sacs, has, with his usual sagacity, not confounded the granular body, or, as he denominates it, "another pulpy substance," with the proper membranes of the sacs. Accordingly, in his account of the relative vascularity of the membranes of the sacs, he, when describing the manner in which a tooth is formed, has taken no notice of the pulpy substance. Dr Blake describes the membranes of the sacs at an early period; Mr Hunter again, in a child at birth, at which time the external membrane is not very vascular, and has assumed somewhat of the appearance of a fibro-cartilage.

the latter reaches the base of the pulp the former disappears, and the interior of the dental sac assumes the villous vascular appearance of a mucous membrane. This change is nearly completed about the seventh or eighth month.

Up to this period little change has taken place in the ten anterior, or in the two posterior or great cavities of reserve. The ten anterior have been gradually receding from the surface of the gum, so as to be posterior, instead of inferior, to the milk sacs. The two or four anterior began about the fifth month to dilate at their distal extremities, across which a fold appears (which is the germ of the future pulp) lying in the direction of the cutting edge of the future tooth; and at the proximal or acute extremities of the cavities two other folds, an anterior and a posterior appear. * These round off the undefined apices of the cavities, and are strictly analogous to the opercula of the milk follicles.

The distal fold gradually acquires the appearance of a tooth pulp, while the proximal disappear by the obliteration of the little undefined space beyond them.

The cavities of reserve have now become tooth sacs, and under this form they continue to recede from the surface of the gum, imbedding themselves in the submucous cellular tissue, which has all along constituted the external layer of the milk sacs, and in which the larger saccular vessels ramify before arriving at the true mucous membranes of the sacs. This implantation of the permanent, in the walls of the temporary tooth sacs, gives the former the appearance of being produced by a GEMMIPAROUS process from the latter.†

The dental groove was originally imbedded in an alveolar groove. As the dental interfollicular septa are developed in the

---

* These two folds are strictly analogous to the opercula of the milk tooth sacs. They never attain, however, the same high developement as those of the latter, remaining in a rudimentary state, apparently in consequence of the almost saccular condition of the cavities of reserve. The existence of these laminæ in a rudimentary state proves, that, in the formation of the permanent teeth, there is a strict adherence to the law of follicular development, even when, in man at least, there is no apparent necessity for it.

† It was this imbedding of the permanent, in the walls of the temporary, tooth sacs which deceived Dr Blake, and led him to suppose that the former derived their origin from the latter. Mr Fox supported the same view of the subject; and Mr Bell, in his own work, (Anatomy, &c. &c. of the Teeth, p. 61,) and more lately in his notes in Palmer's edition of Mr Hunter's Works, Vol. ii. p. 37, has strongly urged the same doctrine. Mr Bell has stated, that Mr Hunter's "account of the manner in which the permanent teeth are formed is exceedingly imperfect;" but it is evident, that, if the account of the origin of these teeth given in the text be correct, Mr Hunter was not in error when he supposed both sets to be of independent origin. Mr Hunter was so correct a thinker, that he did not account the circumstance of contiguity to be a proof of dependence. He was apparently ignorant of the origin of both sets, and in his usual cautious manner, when *describing structure*, makes no observation on the subject. The author of the Edinburgh Dissector holds the same opinion as Mr Hunter on this subject; and in his excellent chapter on the teeth, although he does not disprove the opinions of Dr Blake and others, cautions the student against supposing Mr Hunter to be incorrect on this subject.

former, osseous septa also begin to be formed in the latter. These osseous septa are at first in the form of bridges, but ultimately, at the sixth month, become complete partitions. As the sacs increase in size, the alveoli increase also, and when the permanent form slight projections behind the temporary tooth sacs, niches * are formed for them in the posterior walls of the alveoli. Whilst this increase in the bulk of the sacs and alveoli is going on, there is no proportionate increase in the length of the jaw, in consequence of which the sac of the anterior permanent molar has been insinuating itself into, and at the eighth month, or the full time, is almost wholly imbedded in, the maxillary tuberosity, † and has become situated on a higher level than the milk sacs, during which it has not only drawn the surface of the gum upwards and backwards, but has also lengthened out the great or posterior cavity of reserve.

About this time the fangs of the milk incisives begin to be formed, in the accomplishment of which three contemporaneous actions are employed, viz. the lengthening of the pulp; the deposition of tooth substance upon it; and the adhesion to the latter of that portion of the inner surface of the sac which is opposite to it.

While the fangs of the milk teeth, particularly those in the front of the jaw, are lengthening in the manner now described, the pulps and sacs of the permanent teeth continue to increase, and the bony crypts which contain them to enlarge in proportion, the lower edges of the latter insinuating themselves between the two former. As this process continues, the jaw lengthens more rapidly, and when the infant is eight or nine months old, there is so much room in the alveolar arch, that the anterior permanent molar tooth begins to resume its former position in the posterior part of the dental arch, and the great cavity of reserve again to return to its original size and situation.

About this time the central incisives begin to pass through the gum,—a process which is accomplished in the following manner. The body of the tooth having been fully formed, and coated with enamel, has also been acquiring a portion of its fang, by the triplex action formerly described; in consequence of which, a reaction takes place between the bottom of the socket and the unfinished extremity of the fang. This reaction causes the body of the tooth and the non-adherent portion of the sac gradually to approach, and the former finally to pass through, the surface of the gum. Till the time that the edge of the tooth passes through the gum, the fundus of the sac, and consequently the base of the pulp with the extremity of the fang, never change their common

* Bell, Anatomy, &c. of the Teeth, p. 62.

† Hunter, Nat. Hist. Human Teeth, pp. 101, 102, 103.

relative position in the jaw. At the moment, however, that the tooth passes through the gum, (when the non-adherent portion of the sac resumes its primitive follicular condition, its inner membrane becoming continuous with the mucous membrane of the mouth,) the non-adherent portion of the sac shortens more rapidly than the fang lengthens, in consequence of which the adherent portion with the fang itself separates from the fundus of the alveolus, and the body of the tooth advances through the gum.* A space is thus left between the top of the alveolus and the fundus of the sac, occupied by cellular tissue, and traversed by the vessels and nerves. The alveolar cavity at the same time rapidly adapts itself to the new condition of its contents, advancing its edges so as to clasp the root, which has during these rapid changes been steadily lengthening,—a process which now goes on with greater rapidity, as it is conducted in a comparatively empty space. The pulp continues to lengthen till its base is no larger than the fasciculus of vessels and nerve which enter it. The orifice of the cavity of the tooth also diminishes to the same size, and through it the surface of the pulp becomes continuous with the adherent portion of the sac, and consequently with the mucous membrane of the mouth. The adherent portion of the sac has now attained its maximum, and the free or open portion its minimum size, having been reduced to that narrow portion of the gum which forms a vascular border and groove round the neck of the perfected tooth.†

During the period that the milk teeth have been advancing along with their sockets to their perfect state and ultimate position in the jaw, the permanent sacs have been receding in an opposite direction, and have, as well as their bony crypts, been enlarging, the edges of the latter, insinuating themselves so far between the former and the milk sacs, that at last they are only connected by their proximal extremities, and ultimately, when the lower edges of the crypts sink so far as to have become the posterior lips of the alveoli of the milk teeth, the notches of com-

* The movement of the unfinished extremity of an incisive tooth from the fundus of its alveolus will explain what I have commonly remarked, and what must have been observed by medical practitioners, that from the time that the edge of the tooth appears through the gum, it advances more rapidly than can well be accounted for by the usual rate of lengthening of its fang. This advance is not invariably rapid, but may be observed in all the incisive teeth, if careful daily examination be made during a normal dentition.

† This vascular border may be seen in healthy gums which have not been disturbed by the deposition of tartar, and is beautifully displayed in two wet injected preparations, in the Bell collection, Museum of the Royal College of Surgeons, Edinburgh (Bell, C. iii. No. 25 and 56.)

It is interesting to observe, that one of the first physiological effects of mercury, viz. excitation of the gastro-intestinal compound glands and simple mucous follicles, is also displayed in a similar manner in the borders which surround the necks of the teeth, which are the remains of the free portions of the tooth sacs, while it at the same time acts upon the adherent portions and their submucous tissue, raising the teeth from their sockets, and affecting the jaw from contiguity.

munication between the latter and the permanent alveoli are forced, under the form of foramina, into a position on the anterior surface of the palate, one behind each milk alveolus. The sacs of the bicuspids having assumed a position directly above the milk molars, the hole of communication is never removed from the sockets of the latter.

The cords of communication which pass through these foramina are not tubular, although in some instances a portion of the unobliterated extrafollicular compartment of the original little cavity of reserve may be detected in them. They are merely those portions of the gum which originally contained the lines of adhesion of the depressions for the permanent teeth in the *secondary dental groove*, and which have been subsequently lengthened out, in consequence of the necessarily retired position in which the permanent teeth have been developed, during the active service of the temporary set. The cords and foramina are not obliterated in the child, either because the former are to become useful as "gubernacula," and the latter as "itinera dentium," or much more probably, in virtue of a law, which appears to be a general one in the developement of animal bodies, viz. *that parts or organs which have once acted an important part, however atrophied they may afterwards become, yet never altogether disappear so long as they do not interfere with other parts or functions.*

The sacs of the permanent teeth derive their first vessels from the gums; ultimately they receive their proper dental vessels from the milk sacs, and as they separate from the latter, into their own cells, the newly acquired vessels conjoining into common trunks, retire also into permanent dental canals.

It was stated above, that, in the child at the 7th or 8th month, when the central incisives were passing through the gums, the jaw had lengthened so much as to allow the first permanent molar to retire from the maxillary tuberosity, and to resume in some measure its position downwards and forwards in the same line with the other teeth, and also to reduce the great cavity of reserve to its primitive size. This cavity of reserve now begins to lengthen, to bulge out, and to curve backwards and upwards at its posterior extremity, under the form of a sac, into the mass of the maxillary tuberosity; a papilla or pulp appears in its fundus, and a process of contraction separates it from the remainder of the cavity of reserve, which still adheres to its proximal wall by one extremity, while by the other it is continued into the substance of the gum under the anterior molar. This new sac, which is that of the second permanent molar, now occupies the position in the maxillary tuberosity, which the first permanent did before it. It afterwards leaves this retired position, in consequence of the lengthening of the jaw allowing it to fall downwards and forwards into the line, and on a level with the

other teeth.* Before it leaves the tuberosity altogether, the posterior extremity of the remainder of the cavity of reserve sends backwards and upwards its last offset—the sac and pulp of the wisdom tooth, which speedily occupies the tuberosity after the second molar has left it, and ultimately, when the jaw again lengthens for the last time, at the age of nineteen or twenty, takes it place at the posterior extremity of the range of the adult teeth.

The wisdom teeth are the second products of the posterior or great cavities of reserve, and the final effects of developement in the *secondary dental groove.*†

In the lower jaw, as in the upper, dentition commences in a deep narrow groove, situated between the lip and a semicircular lobe. This groove, instead of terminating in a simple curve posteriorly, as in the upper jaw, becomes shallow, and assumes a sigmoidal form upon the surface of the posterior bulbous ovoidal portion of the lobe.

About the seventh week the lip becomes very loose, and separates widely from the lobe, between which and the former a ridge appears, growing from behind forwards, and dividing the original groove into two, an outer one,—the labial duplicature of mucous membrane, and an inner,—the *primitive dental groove.* This ridge, which as in the upper, does not yet extend to the incisive portion of the jaw, is flat, or in the same continuous plane with the bottom of the dental groove, and its lip is turned out, or overhangs the labial mucous membrane. The inner lip of the groove is formed by the semicircular lobe, which has become thin, and arched over the groove, particularly anteriorly, where it is cut into four festoons, two on each side of the median line ; and posteriorly, where it still retains the appearance of an oval lobe, from under which the outer lip or ridge appears to proceed. The groove curves inwards between the two lips posteriorly, under a form which is evidently a developement of the original sigmoidal groove.

Near the posterior extremity of the groove there is an elevation of a small portion of its floor, which speedily becomes the germ or papilla of the inferior anterior milk molar tooth,—the second

* The curved lines which the posterior cavities of reserve, and the sacs of the molar teeth, describe in their progress to and from the maxillary tuberosity, and the coronoid process, and the peculiar position in which the pulps are consequently developed, explain satisfactorily certain normal and abnormal conditions of these teeth. 1. The curves which the combined grinding surfaces of the molar teeth present, convex downwards and backwards in the upper jaw, concave upwards and forwards in the lower. 2. The peculiar manner in which the fangs of the molars, particularly the inferior, are bent backwards. 3. The occasional horizontal position of the wisdom teeth, the crowns of the inferior being directed forwards, those of the superior backwards. This abnormal position is the cause of much annoyance and danger to the patient, and of difficulty to the surgeon.

† It is probable that the successive dentitions of the elephant are conducted in a cavity of reserve, which must consequently exist even in the adult animal, till a late period of its life. If such be the case, the molar dentition of the elephant, and the formation of the human adult molars, are analogous processes.

tooth which appears in the primitive developement of the human body. During the eighth week the elevation, already mentioned, becomes a papilla, lengthened from behind forwards, and flattened transversely. About the same time another papilla, bounded by a notched lamina, similar to those in the upper jaw, makes its appearance further forward in the groove. This papilla is the germ of the inferior milk canine. The dental groove is about the same time continued forward to the median line, not by the advancement of its outer ridge, but by the elevation of its floor. Its posterior portion also has become wider, and not so curved.

During the succeeding week the incisives make their appearance, the centrals first.

From this time all the eight papillæ continue to increase. The notched laminæ shoot inwards to the inner lip of the groove, near which they meet and join slight projections from it. About the eleventh or twelfth week the germ of the posterior milk molar appears in the curved portion of the groove, and is developed in the usual manner.

Crescent-like depressions appear in the secondary groove, on the inner side of the mouths of the milk follicles, as in the upper jaw.

The secondary groove adheres, leaving a posterior open portion, in which are developed the papilla and follicle of the first permanent molar. This follicle closes, as well as the lips of the portion of groove above it. There are now in the jaw ten milk tooth sacs, two permanent tooth sacs, ten anterior cavities of reserve, and two great or posterior cavities of reserve ;* the ten anterior for the developement of the incisives, canines, and bicuspids ; the two posterior for that of the second and third molar,† the coronoid process acting the part which the maxillary tuberosity did in the upper jaw.

Section III.

1.—*On the Division of Dentition into Stages.*—As dentition is a process, not only very complicated in its details, but of very lengthened duration, extending over nearly eight months of intra-uterine, and above twenty years of extra-uterine existence, the understanding and further investigation of it may be facilitated by dividing it into stages. The most natural division, one which is not artificial, but clearly indicated by the phenomena themselves, is into three stages, according to the position of the pulp in re-

* The mucous membrane constituting the cavities of reserve, exists in a condition which has hitherto been considered by anatomists as peculiar to the serous membranes. A dental cavity of reserve is a shut sac, lined by a true mucous membrane, which is isolated from the general mucous system, and performs no special function, till it is called upon to supply what it alone can afford, materials for the developement of a tooth.

† The cavities of reserve are occasionally somewhat undefined, two or three being conjoined, particularly posteriorly. Sooner or later, however, they become distinct. The great cavity frequently stretches forwards over the sacs of the milk molars.

lation to its containing cavity; 1*st*, follicular stage; 2*d*, saccular; 3*d*, eruptive. We ought probably to consider, as anterior to the follicular, the papillary stage* during which the follicle or sac does not exist, and the future pulp is a simple papilla on the free surface of the gastro-intestinal mucous membrane. As this stage, however, is short in its duration, and simple in its details, it may be included in the first stage.

The first or follicular stage comprehends all the phenomena which present themselves from the first appearance of the dental groove and papillæ till the latter become completely hid by the closure of the mouths of their follicles, and of the groove itself. It is upon this hitherto unknown stage of dentition that I have insisted so much in the former sections of this paper.

The second or saccular stage is the one with which anatomists have been so long familiar, during which the papillæ are pulps, and the open follicles which contain them are shut sacs, when the tooth-substance and the enamel, constituting the teeth themselves, are deposited. It is during this stage, also, that some of the most interesting phenomena in the formation of the alveolar processes present themselves.

The third or eruptive stage includes the completion of the teeth, the eruption and shedding of the temporary set, the eruption of the permanent, and the necessary changes in the alveolar processes.

When viewed in reference to an individual tooth, these three stages are distinct, but when viewed in reference to both sets, and to the whole process of dentition, they become somewhat intermingled.

When considered in the latter point of view, we may state that the follicular stage commences at the sixth or seventh week, and terminates at the fourth or fifth month of intra-uterine existence,—that the saccular commences at the termination of the first, and lasts for certain of the teeth till the sixth or eighth month, and for others till the twentieth or twenty-fifth year of extra-uterine existence, and that the third or eruptive commences at the sixth or eighth month, and lasts till the twentieth or twenty-fifth year.

* Most anatomists have supposed the germs of the teeth to appear as shut sacs, full of a fluid, the pulps being formed by inspissation of the latter, or by developement from the walls of the former. Neither Mr Hunter nor Mr Bell have stated anything very definite on this subject. The pulp must be considered as the principal part of the organ, and as the element which appears first. The sac is a mere subsidiary part, supplied for purposes of developement and nourishment. Handbuch der Anatomie des Menschen, von H. Hildebrandt, besorgt. von E. H. Weber, Erste Band, p. 212; Handbuch der Entwickelungs-geschichte des Menschen von Valentin, p. 482; Arnold, Salzburg, Medicinisch Chirurgisch Zeitung, 1831, Erster Band, p. 236; Cruveilhier, Anatomie Descriptive, Vol. i. p. 518; Serres, Essai sur l'Anatomie, &c. des Dents, p. 59. Ph. Fr. Blandin, Anatomie du Systeme Dentaire, &c. p. 87; Blake, Essay on the Human Teeth, p. 2.

On the Anterior Permanent Molar Teeth—The anterior permanent molar is the most remarkable tooth in man, as it forms a transition between the milk and permanent set. If considered anatomically, it is decidedly a milk tooth; if physiologically, a permanent one. In a former part of this paper, it was stated that the papilla and follicle of this tooth, were developed in a small portion of the primitive dental groove, which remained open for that purpose till the fourth or fifth month, while all the other permanent teeth were productions, not from the primitive groove, but from small non-adherent portions of the secondary groove, which lay in a level superior to the shut orifices of the sacs of all the milk teeth, and of the tooth in question,—the first permanent molar. In reference to its function, however, as the most efficient grinder in the adult mouth, we must consider it as a permanent tooth. It is a curious circumstance, and one which will readily suggest itself to the surgeon, that, laying out of view the wisdom teeth, which sometimes decay at an early period from other causes, * the anterior molars are the permanent teeth, which most frequently give way first, and in the most symmetrical manner, and at the same time, and frequently before the milk set.

On the Tardy Developement of the Superior Incisive Teeth.—A reference to the first section of this paper will show that at the ninth week, when the papillæ of the superior incisives are quite distinct, those of the inferior are with difficulty recognized. This is a fact which may be included under a law which will be more fully referred to afterwards, viz. that the dentition of the upper precedes, and is always in advance of the same process in the lower jaw. A week or two later, however, when the papillæ of the inferior incisives are imbedded and hid in deep follicles, those of the superior are nearly in their original condition. Although the latter recover in some degree their lost ground, yet, as every one knows, the inferior central incisive almost always cuts the gum before the superior, and the lateral sometimes does so also. In order to explain this apparent exception to the law above mentioned, it will be necessary to go a little into the history of the inter-maxillary bones, in doing which reference must necessarily be made to some of the other bones of the face and head.

When the superior portion of the large common nasal buccal and pharyngeal cavity is exposed in an embyro of the sixth or seventh week, by removing the lower jaw, we observe the boundary of the future palate to be defined by what has been denominated in a former section the horse-shoe lobe (*c*, Fig. 2.) Attached to the posterior inner edges of this lobe, two other lobes are seen. These grow from behind forwards, and from without

* Bell, Anat. &c. of the Teeth, p. 133.

inwards, and complete the palate by joining in the median line, being assisted in doing so posteriorly by two other smaller lobes, behind the posterior extremities of the horse-shoe lobe. In the two first lobes become developed the palatine plates of the superior maxillary bones, and in the two smaller posterior the palatine plates of the palate bones.

The bar (*h*, Figs. 2 and 4,) which ultimately coalesces below with the median line of suture of the four last mentioned lobes, is proved by developement to contain the nucleus of the vomer.

The median lobule (*m*) and its two lateral and anterior appendages (*n n*) form the anterior division of the embryonal palate. Of these three, the two lateral are observed in the course of developement to contain the nuclei of what are usually denominated the inter-maxillary bones. With regard to the median it may be stated that, as all the other lobules which appear in the soft pulpy texture of the fœtal palate, are proved by developement to contain the nuclei of all the well known bones of this region, I am inclined to consider it as indicative of the existence of the rudiment of a bone also, especially when the interesting antagonism, which I will show exists between it and the lateral lobules, is taken into consideration.*

As the object of this part of my paper, however, is not to discuss the osteogenesis of the human head, but to explain why the inferior incisive teeth, although later in their appearance, are yet more rapid in their progress than the superior, I shall now recall some circumstances formerly detailed regarding the developement of the three intermaxillary lobules, immediately before and for some time after the appearance of the incisive papillæ.

During the seventh week the three lobules are equal, and there is no appearance of either the upper or lower incisive teeth.

During the eighth week, the median lobule has increased relatively, and the laterals only absolutely; while as yet there is no appearance of either the upper or lower incisives.

During the ninth week the median has diminished relatively, and in the transverse direction; the laterals again have increased relatively and also in the transverse direction. This relative transverse increase of the lateral lobules is synchronous with the first appearance of the upper incisives. The inferior incisives are so indistinct at this time, as to be recognized with difficulty as slight bulgings on the floor of the dental groove.

---

* A small cartilaginous body exists in the median inter-maxillary lobule of the child at birth. It is situated in front of the inferior orifice of the naso-palatine canal, and between the mucous membrane and periosteum.

The median inter-maxillary lobule exists in the adult palate, and may be felt behind and between the central incisives. Median inter-maxillary bones and cartilages exist in certain of the lower vertebrata.

The bar-like vomer of the human embyro at the sixth and seventh week, reminds the anatomist of the adult vomer of the lower vertebrata.

During the next fortnight, the relative size of the median and lateral lobules remains the same, and there is no further developement of the superior incisives. During the same period the inferior incisives have been rapidly increasing.

Afterwards the median undergoes much relative transverse diminution, while at the same time the laterals acquire a remarkable relative increase, which is accompanied by a corresponding developement of the superior incisives ; but the inferiors have now got so much in advance as to retain their advantage ever after.

On the Laws which regulate the developement of the Pulps and Sacs, and the period of appearance of each of the Tooth Germs.—In the description which has been given of the earlier phenomena of dentition, it will be perceived that many of them range themselves under the laws recognized by MM. G. St Hilaire, and Serres, viz. the law of symmetry (loi de symmetrie,) the law of conjunction (loi de conjugaison,) the law of balancing or antagonism (le balancement des organes,) and the law of excentric developement (loi du developpement excentrique.)

The primitive and secondary dental grooves, the follicles, the cavities of reserve, the osseous alveoli of the milk teeth and their septa, are all formed originally of two halves, which ultimately join according to the laws of symmetry and conjunction.

The pulps of the milk teeth* with their notched laminæ are productions from the external lip or ridge of the groove. The interfollicular septa,—and the osseous alveolar septa, are also developed from without inward, (loi du devcloppement excentrique.)

I have already pointed out the beautiful example of antagonism which exists between the median and lateral elements of the intermaxillary system, and I may now point out, from among the facts formerly detailed, a few instances of the same kind, which must be referred to the same general expression, (loi de balancement.)

1.—Before the tenth week the upper lip is full and prominent, but at that time it begins to recede and gradually to disappear anteriorly, so as to expose the follicles and papillæ of the incisive teeth. It afterwards begins to regain its former position and size, and at the fourteenth or fifteenth week it is as large as the inferior, which from the first has not changed its appearance.

At the tenth week, when the lip begins to recede, the maxillary palate advances its anterior extremity, so as to conceal in some degree the intermaxillary palate (median and lateral lobules.) When the middle of the lip has disappeared, the maxillary has not only encroached upon the intermaxillary, but has also thrown itself into a bundle of irregular folds at its anterior part. As the maxillary

* It is a curious fact, that the first tooth germs which appear, viz. those of the superior anterior and inferior anterior milk molars, are not productions from the external lip of the dental groove, but bulgings on its floor.

palate retires, and the folds become regular crenated rugæ, the anterior part of the lip again appears, and at the fifteenth or sixteenth week, it is full and prominent, when the maxillary palate has retired to its proper position.

2.—When the outer lip of the primitive dental groove sends off the laminæ, which constitute the greater part of each of the interfollicular septa, and the floor of the secondary groove, the lip itself almost disappears.

The inner lip, again, which contributes a very small share towards the accomplishment of this process, becomes so much enlarged as to cover the whole groove.

3.—The external and internal lips of the primitive dental groove are, originally, equally prominent. The former, when it sends off the interfollicular septa diminishes, while the latter increases. When all the follicles of the primitive groove have been completed, the external lip begins to increase, and the internal to diminish. This increase of the external lip goes on after the closure of the secondary groove, until, at the fifth month, it becomes very prominent, and is divided into an incisive, a canine, and molar portion, each of which has a general similarity in shape to the acting portions of the corresponding divisions of the future tooth ranges. As long as it remains in this condition it is employed by the infant as a masticating organ. During this period the internal lip has altogether disappeared, except a small portion posteriorly; but a short time before the milk teeth appear, it again increases, and the raphe of the dental groove, instead of being hid behind the base of the external lip, is situated on the ridge of the dental arch, which now, as at first, is composed of two equally developed portions. The raphe forms a little border in the situation just mentioned, and is familiar to the eye of the surgeon, who, by its disappearance at any particular point, can satisfy himself of the proximity of the milk tooth under it.

Careful observation of the whole process of Dentition in man leads to the following conclusions:—

Milk Teeth.—1. The milk teeth are formed on both sides of either jaw, in three divisions, a molar, a canine, and an incisive, in each of which dentition proceeds in an independent manner.

2.—The dentition of the whole arch proceeds from behind forwards—the molar division commencing before the canine, and the latter before the incisive.

3.—The dentition of each of the divisions proceeds in a contrary direction, the anterior molar appearing before the posterior, the central incisive before the lateral.

4.—Two of the subordinate phenomena of dentition also obey this inverse law, the follicles closing by commencing at the median line, and proceeding backwards, and the dental groove disappearing in the same direction.

5.—Dentition commences in the upper jaw, and continues in advance during the most important period of its progress. The first tooth germ which appears is that of the *superior* anterior molar, which precedes that of the *inferior* anterior molar.

The apparent exception to this law in the case of the inferior incisive has already been explained.

Permanent Teeth.—6. The germs of the permanent teeth, with the exception of that of the anterior molar, appear in a direction from the median line backwards.

7.—The milk teeth originate, or are developed, from the mucous membrane.

8.—The permanent teeth, also originating from mucous membrane, are of independent origin, and have no connection with the milk teeth.

9.—A tooth pulp and its sac must be referred to the same class of organs as the combined papilla and follicle from which a hair or feather is developed, viz. bulbs. *

Explanation of the Figures.

a. Fig. 1. A tooth-germ—a bulging on a mucous membrane.

b. Diagrams illustrative of the three stages of dentition.

Fig. 1. Follicular stage.

Fig. 2. Saccular stage.

Fig. 3. Eruptive stage.

c. Diagrams illustrative of the formation of a temporary and its corresponding permanent tooth from a mucous membrane.

Fig. 1. Mucous membrane.

Fig. 2. Mucous membrane with a granular mass deposited in it.

Fig. 3. A furrow or groove on the granular mass. (Primitive dental groove.)

---

* An abstract of this paper was read at the last meeting of the British Association for the Advancement of Science.

Dr Allen Thomson stated to me at that time, that he had no doubt that the fact of the *milk* tooth sacs being at one period open follicles had been observed, but that, then, he could not inform me where I could find it mentioned. I saw Dr Thomson in Edinburgh a few weeks afterwards, when, on looking into Valentin's work on Developement (Handbuch der Entwickelungs-geschichte des Menschen,) he pointed out to me the fact, that Arnold had observed that the milk tooth sacs were formed by a duplicature of the mucous membrane of the mouth, and had inserted a notice of the discovery in the Salzburg Med. Chir. Zeitung, 1831, p. 236. In order that Professor Arnold's discovery (which appears to have been altogether overlooked both in this country and in France) may be more generally known, I will give all his facts as he has recorded them. His notice occupies less than a page, and I am not aware that he has extended it elsewhere. At p. 236, loc. cit. he has observed, "in an embryo at the ninth week, we may perceive in both jaws, on the projecting edges of the gums, a proportionally pretty deep furrow, with ten depressions in it; a little later we may see a flat surface, on which there are many openings, communicating with small sacs, into which fine bristles may be passed. At the third month the sacs of the second molars may be seen communicating with the cavity of the mouth by small holes. The openings of the remaining sacs are soon closed by the mucous membrane of the mouth.

"The sacs of the permanent teeth are also formed immediately from the mucous membrane of the mouth, partly at the fourth month of fœtal existence, partly to-

Fig. 4. A papilla on the floor of the groove, (a tooth germ.)

Fig. 5. The papilla inclosed in a follicle in the bottom of the groove, (the latter in the condition of a secondary dental groove.)

Fig. 6. The papilla acquiring the configuration of a pulp, and its sac acquiring opercula. The depression for the cavity of reserve behind the inner opercnlum.

Fig. 7. The papilla become a pulp, and the follicle a sac, in consequence of the adhesion of the opercular lips. The secondary dental groove in the act of closing.

Fig. 8. The secondary groove adherent, except behind the inner opercnlum, where it has left a shut cavity of reserve for the formation of the pulp and sac of the permanent tooth.

Fig. 9. The last change rendered more complete by the deposition of the granular body, (the enamel organ of Hunter, Purkinje, and Raschkow.) Deposition of tooth substance commencing.

Fig. 10. The cavity of reserve receding from the surface of the gum, and dilating it at its distal extremity, in which a pulp is forming. Rudimentary opercula developing near its proximal extremity, and dividing it into a follicular and an extrafollicular compartment. Temporary tooth pulp nearly covered with tooth substance, and granular body almost absorbed.

Fig. 11. The cavity of reserve become a sac with a pulp, and further removed from the surface of the gum. Temporary tooth pulp covered with tooth substance, and granular body absorbed. (See Hunter, Nat. Hist. of Human Teeth, p. 95.)

Fig. 12. The temporary tooth acquiring its fang by the triple action described in the paper, and its sac approaching the surface of the gum.

Fig. 13. The fang of the temporary tooth longer, and its sac touching the mucous membrane of the mouth.

Fig. 14. The temporary tooth sac again a follicle; free por-

---

wards the end of that period, partly at birth. Once only, in a new-born child, I observed behind the most prominent edge of the gums, several openings which led to the sacs of the incisives and canines, and which are usually already obliterated before birth."

These are all the facts Arnold has recorded, and from them, it appears that he was acquainted at that time with the secondary dental groove, the ten milk follicles, and the ultimate closure of the latter. So far as we can judge from his brief notice, he appears to have been unacquainted with the mode of formation of the permanent follicles, supposing them to be formed immediately (unmittelbar) from the mucous membrane of the mouth, an opinion which is very prevalent among the continental anatomists. I can only account for the openings he mentions in the new-born child by arrest of developement, or by supposing that he had observed a few of the Tartar glands of Serres, (Glandes dentaires, Essai, &c. p. 28,) which are best seen at the period to which he alludes.

Having now mentioned all the facts which Professor Arnold has published, I may be allowed to state, that I had made out all the facts detailed in this paper, before I was aware that any of them had been on record; that I had given an account of them at the last meeting of the British Association, before I knew of Professor Arnold's notice; and that this paper was in the hands of the Editor of the Edinburgh Med. and Surg. Journal before I had an opportunity of seeing the Salzburg periodical.

I had also demonstrated the principle facts in the follicular stage of dentition in 1835, to Mr Nasmyth, to whom I am deeply indebted for the information he has given me respecting the anatomy and surgery of these organs, and in whose cabinet I at that time deposited preparations illustrative of the facts.

tion of the latter becoming shorter, and fang of the tooth receding from the bottom of its socket. Permanent tooth sac removing further from the surface of the gum.

Fig. 15. The temporary tooth completed. Free portion of the sac become the vascular border of the gum ; adherent portion become what is commonly denominated the periosteum of the fang, but which in fact is a triplex membrane, viz. mucous membrane, submucous tissue, and periosteum of alveolus or jaw bone. The permanent tooth sac much removed from the gum, but connected with it by a cord which passes through the foramen behind the temporary alveolus.

Fig. 16. The fang of the permanent tooth lengthening, and the crown approaching the gum. Fang of temporary tooth undergoing absorption.

Fig. 17. The same change more advanced.

Fig. 18. The permanent tooth appearing through the gum. Shedding of the temporary tooth.

Fig. 19. The perfected permanent tooth.

Fig. 20. The shed temporary tooth.

d. Diagrams illustrative of the formation of the three molar teeth from the non-adherent portion of the primitive dental groove.

Fig. 1. The non-adherent portion of the primitive dental groove.

Fig. 2. The papilla and follicle of the first molar on the floor of the non-adherent portion, which is now a portion of the secondary groove.

Fig. 3. The papilla and follicle of the first molar become a pulp and sac. The lips of the secondary groove adhering, so that the latter has become the posterior or great cavity of reserve.

Fig. 4. The sac of the first molar increased in size, and advanced along a curved path into the substance of the coronoid process or maxillary tuberosity. The cavity of reserve lengthened out or advanced along with it.

Fig. 5. The sac of the first molar returned by the same path to its former position. The cavity of reserve again shortened.

Fig. 6. The cavity of reserve sending backwards the sac of the second molar.

Fig. 7. The sac of the second molar advanced along a curved path into the coronoid process or maxillary tuberosity. The cavity of reserve lengthened for the second time.

Fig. 8. The sac of the second molar returned to the level of the dental range. The cavity of reserve shortened for the second time.

Fig. 9. The cavity of reserve sending off the pulp and sac of the wisdom tooth.

Fig. 10. The sac of the wisdom tooth advanced along a curved line into the maxillary tuberosity or coronoid process.

Fig. 11. The sac of the wisdom tooth returned to the extremity of the dental range.

PRINTED BY JOHN STARK, EDINBURGH.

Mr. GOODSIR on the Origin and Developement of the Pulps and Sacs of the Human Teeth.